

ATTITUDE DETERMINATION OF THE ANTARCTIC SOUNDING ROCKETS S-310JA-11 AND -12

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Abstract: The attitude of two sounding rockets, S-310JA-11 and -12 launched at Syowa Station on May 29 and July 12, 1985, were determined using magnetometers and horizon aspect sensors. The spin rate of the S-310JA-11 rocket was 0.57 rps and the coning half angle of the precession was 8.8° with the period of 308 s. The spin rate of the S-310JA-12 rocket was 0.59 rps and the coning half angle of the precession was 25.0° with the period of 292 s.

1. Introduction

It is the most fundamental requirement to determine the attitude of rocket during the flight, not only from technological need for vehicle stabilities but also for analyses of experimental data taken by on board instruments. Two sounding rockets were launched from Syowa Station, Antarctica in the austral winter of 1985, as a part of the International Middle Atmosphere Program, by the wintering party of the 26th Japanese Antarctic Research Expedition (JARE-26).

These rockets carried triaxial fluxgate magnetometers to measure three orthogonal components of the geomagnetic field. It has two purposes for the geomagnetic field measurement, one is to study field-aligned current, ionospheric current and magnetic field variation associated with aurora and the other is to measure the angle between the rocket spin axis and the geomagnetic field vector. The Z-axis of the sensor was parallel to the spin axis and the other two sensors (X-axis and Y-axis) located on a plane perpendicular to the spin axis.

After the nose cone was opened during the rocket ascending, the magnetic sensors were extended by a rigid boom of 39.4 cm in length in order to reduce the magnetic disturbance from the rocket body and payload instruments. The range of measurable magnetic field was $+60000$ to -60000 nT, and the resolution was 1.8 nT. The sampling time was 10 ms and the noise level was less than 5 nT. The magnetic offset and bias field had been calibrated in a magnetic shield room of ISAS (Institute of Space and Astronautical Science) before the launch. The magnetic bias was 504 nT in the S-310JA-11 rocket and 403 nT in the S-310JA-12 rocket at the sensor position.

However, from the analysis of flight data, it was found that the most fitting values of the magnetic bias were 410 and 559 nT, respectively.

Both magnetometers were completely operated during the flight, and they provided us satisfactory geomagnetic field data. Three dimensional attitudes were determined by using magnetometers and horizon aspect sensors.

2. Results of Attitudes

2.1. Attitude of the S-310JA-11 rocket

The antarctic sounding rocket S-310JA-11 was launched from Syowa Station at 0059:53 UT on May 29, 1985, with the launching azimuth angle of 110° and the elevation angle of 80° .

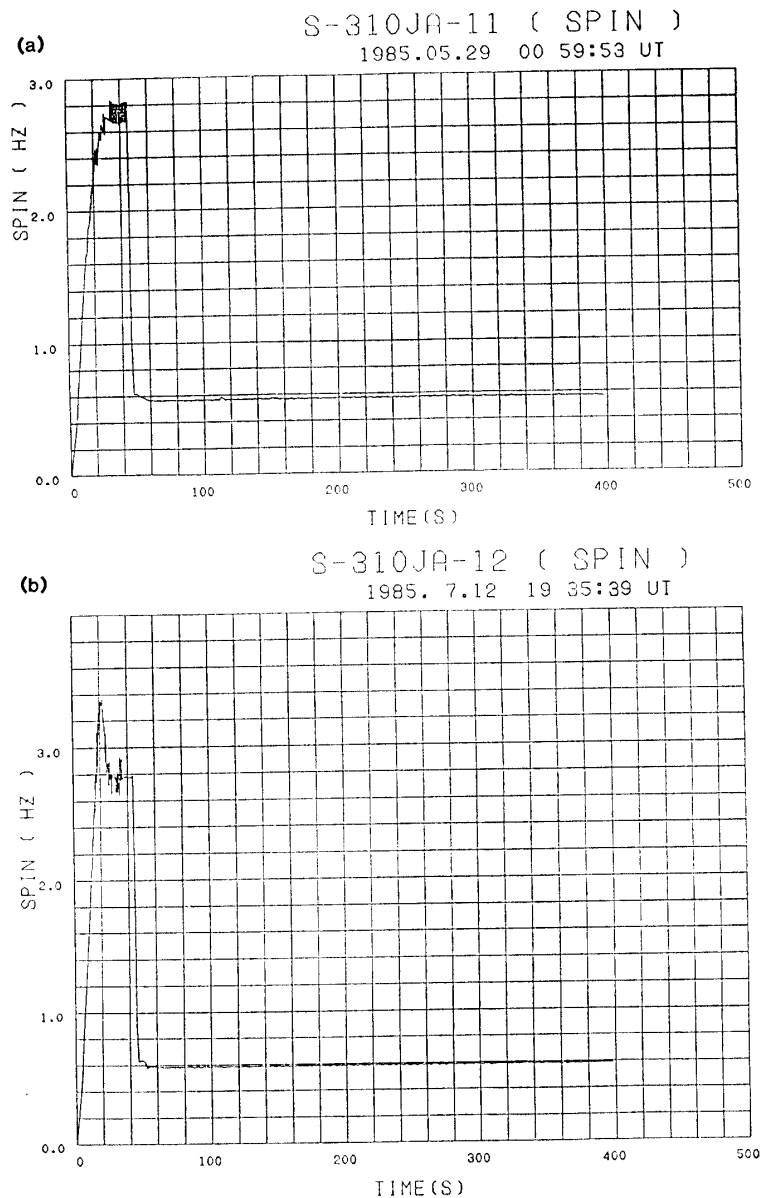


Fig. 1. Time dependence of the spin rate for the S-310JA-11 rocket (a) and -12 rocket (b).

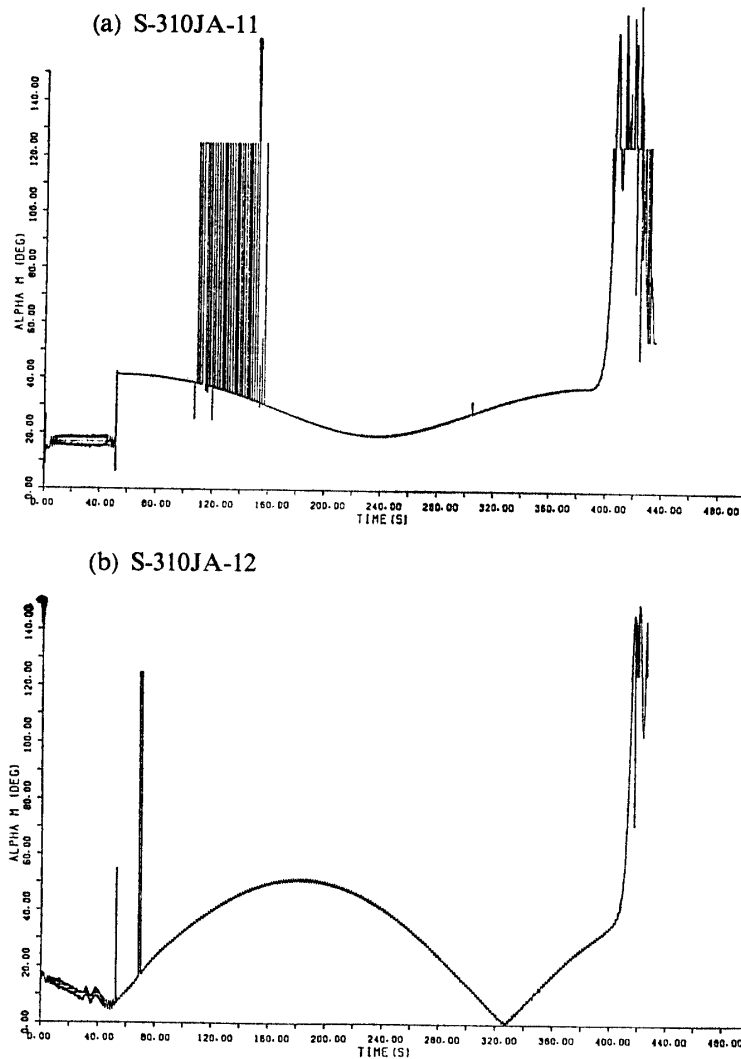


Fig. 2. The angle between the spin axis and the geomagnetic field line for the S-310JA-11 rocket (a) and -12 rocket (b).

The spin frequency of the rocket is shown in Fig. 1a. The spin rate is slowed down from 2.86 to 0.57 rps by a yo-yo despinner at the time of 45 s after the launch. Figure 2a shows the angle between the rocket spin axis and the geomagnetic field line during the flight. In this figure, it is found that a precession started 55 s after the launch by the deployments of many kind of antennas and sensor booms. The conical half angle of the precession was 8.8° and the period was 308 s.

Figure 3 shows the orientation of the rocket spin axis, that is absolute attitude, on a stereographic projection. In this figure, the origin of the circle corresponds to the zenith direction and the circumference is applicable to the horizon at Syowa Station. It is found that the flight attitude of the rocket is very stable as compared with other antarctic sounding rockets.

2.2. Attitude of the S-310JA-12 rocket

The antarctic sounding rocket S-310JA-12 was launched from Syowa Station at

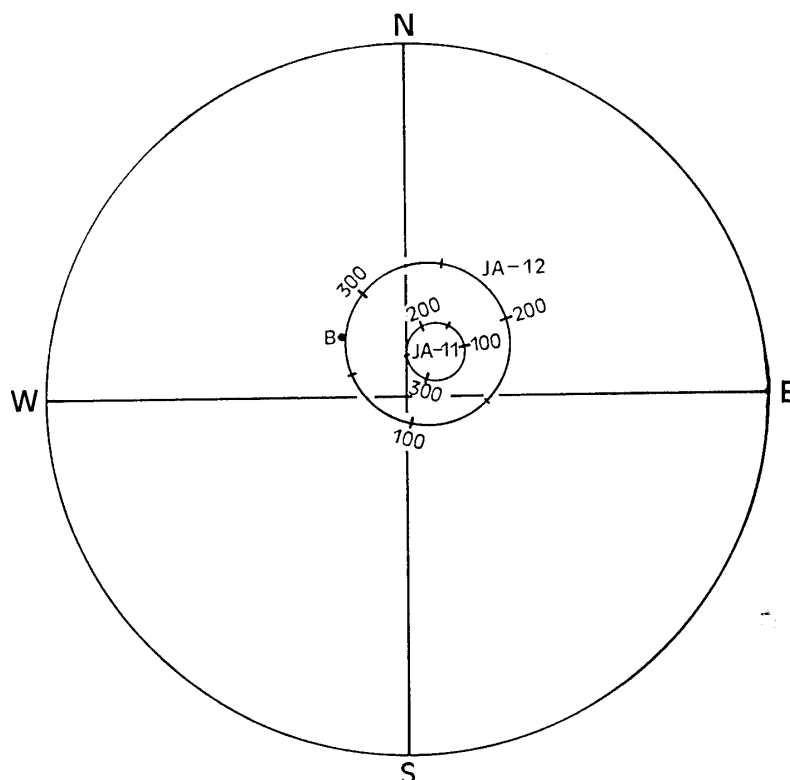


Fig. 3. Absolute orientations of two sounding rocket axes on the Wulf's stereographic projection.

1935:39 UT on July 12, 1985, with the launching azimuth angle of 313° and the elevation angle of 80° . This azimuth angle is the same as the declination of the geomagnetic field at Syowa Station.

The spin rate is shown in Fig. 1b. It is decreased from 2.86 to 0.59 rps by a yo-yo despinner. Figure 2b shows the angle between the spin axis of the rocket and the geomagnetic field during the flight. It is found that the conical half angle of the precession was 25.0° with the period of 292 s. The precession angle was relatively large in comparison with other antarctic sounding rockets. The absolute attitude of the rocket is shown in Fig. 3. This attitude was determined by a computer simulation, because it has ambiguity in the two cone intersection method using the measured data of the magnetometer and the horizon aspect sensor.

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